Building Condos For Oysters

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Sponsorship & Funding

Houston Lighting & Power Company (HL&P), The Port of Houston Authority (PHA), and the National Marine Fisheries Service jointly sponsored a Galveston Bay National Estuary Program Action Plan Demonstration Project (APDP) to construct a 5-acre oyster reef in Galveston Bay utilizing 12,100 yds^3 of coal combustion byproduct (CCB) pellets in the spring of 1993. The primary objective of the project was to demonstrate that a relatively large oyster reef constructed with CCB in Galveston Bay could be both biologically successful and cost effective, relative to natural shell.

The Port of Houston Authority was designated as the project's grant recipient and provided $200,000 in non-federal matching funds for the project. The Environmental Protection Agency (EPA) provided National Estuary funds totaling $91,880. In addition, HL&P provided a partner contribution of $200,000 and JTM Industries, a contractor of HL&P, contributed $100,000 of in-kind support for CCB pellet production. EPA managed the cooperative agreement with PHA and was responsible for approving the Quality Management Plan and Quality Assurance Project Plan. The National Marine Fisheries Service furnished federal agency sponsorship for the project and played an active role in project management.

Priority Problem

Loss of habitat and declines in living resources were identified by the Galveston Bay National Estuary Program as priority environmental problems for Galveston Bay. The Species Population Protection Action Plan in the Galveston Bay Plan describes the priority problem thusly: "Certain species of marine organisms and birds (such as blue crabs and birds classified as wading marsh feeders) have shown a declining population trend, with primary suspected causes identified as loss of habitat, fishing, impingement, and other types of human intervention. Because species within the estuarine environment are dependent on one another for maintenance of the food chain, the preservation of species populations is critical to the ecological health of the Galveston Bay system." To address this problem, the Plan specifically promotes the development of oyster reefs using alternate materials, with CCB a principal candidate.

Reef construction with alternate materials such as CCBs can provide valuable habitat for the American oyster (*Crassostrea virginica*) and a host of infaunal and epifaunal organisms. These organisms are important as food for recreationally and commercially important marine fishery species, such as penaeid shrimp (*Penaeus sp.*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), sheepshead (*Archosargus probatocephalus*), southern flounder (*Paralichthys lethostigma*) and spotted seatrout (*Cynoscion nebulosus*). Filter feeding oysters also have enormous potential to cleanse point and non-point source pollutants from the water column, helping improve water quality in Galveston Bay.

Historical Perspective of Ash Utilization In Marine Applications

Utilization of ash material in marine structures was noted as far back in history as the days of the Roman Empire. The Romans employed volcanic ash in mortar that was used to construct jetties and revetments in the first century. Some of those structures still stand today. In more modern times, nations around the world have used coal ash, or CCBs, to construct marine shoreline protection structures and various types of artificial reefs to enhance the marine ecosystem. Japan has been a leader in the development of artificial reef construction utilizing CCB materials. Other countries using CCB materials in this manner include the United Kingdom (Collins et al., 1991; Jensen et al., 1991), The Netherlands (Bolt and Snell, 1986), Denmark, Germany, Turkey, Israel (Zimmels et al., 1991), Taiwan (Kuo et al., 1991) and the Philippines.

In the last 20 years, researchers in the United States have made significant progress in evaluating the environmental suitability of CCB materials in the marine environment. In the 1970's, the State University of New York at Stoneybrook initiated a study to determine the feasibility of utilizing CCB blocks in the marine environment as fish reef habitat (Woodhead et al., 1985; 1986). This study was conducted over a period of about 10 years with extremely positive results. In 1984, the University of Delaware developed a CCB finfish reef off Delaware near the Indian River Inlet, again with beneficial results (Eklund, 1988). Three years later the University of Delaware first tested CCB materials as oyster cultch in Chesapeake Bay (Price, 1987). Also in 1987, Florida Power Corporation developed a small CCB block reef in the Gulf of Mexico near Cedar Key, Florida (Livingston et al., 1991). Each project contributed to an ever expanding data base that strongly supported the safe application of these materials in marine related projects throughout the United States.

In 1988, HL&P and Texas A&M University at Galveston (TAMUG) initiated studies to investigate the potential for utilization of CCB derived oyster cultch in the coastal bay systems of Texas (Baker et al., 1991). Since that time, seven oyster reefs (including this APDP site) of various sizes have been constructed throughout the Galveston Bay system. Under the direction of Drs. Sammy Ray and Andre Landry, TAMUG conducted studies at each site to evaluate the biological and environmental suitability of CCB substrate. Conclusions reached by these diverse efforts revealed that CCB materials are environmentally acceptable, provide excellent substrate for the attachment

of oysters and other marine fouling organisms, and exhibit structural strength characteristics that make them prime candidates for future marine applications.

Project Planning

Due to the complexity of the APDP, an Artificial Reef Management Steering Committee (ARMS) was formed to assist project managers (HL&P and PHA) in outlining scheduling issues, regulatory agency permit requirements, reef deployment criteria, reef configuration, and biological monitoring programs. This adhoc committee was comprised of 26 individuals from State and federal regulatory agencies, commercial fishing interests, recreational fishing interests, environmental advocacy groups, and regional business interests. A list of environmental concerns regarding utilization of CCB material in the marine environment was developed during ARMS Committee planning meetings. Regulatory agency representation on the ARMS required extensive environmental testing outside the original scope of the project prior to permit approval. Permit approval hinged on results from the following tests:

- A complete elemental analysis of the CCB pelletized material, including a list of 65 different elements,
- Additional bioaccumulation tests on oysters growing on established prototype reefs, the Advanced Technology Program Reef (1.25 acres), and when appropriate, on the 5-acre APDP reef,
- Expansion of the list of elements examined during prototype reef studies to include the Texas Department of Health's 20 elements of human health concern,
- Perform indepth statistical analysis on all sets of bioaccumulation data to determine if significant differences occur with increased size of this APDP CCB reef,
- The Texas Department of Health should conduct a Human Health Risk Assessment on bioaccumulation data to determine health risks involved with the consumption of oysters grown on CCB substrate, and
- Additional Toxicity Characteristic Leaching Procedure metals testing of CCB pellets prior to deployment.

An Independent Review Team (IRT) comprised of 11 independent scientists and experts was organized to review all scientific monitoring plans, procedures, data analysis, and reported results. The IRT made recommendations to the ARMS committee regarding project effectiveness and provided guidance in maintaining quality in data analysis and reporting. Texas A&M University at Galveston was selected by the IRT to conduct biological field assessments of the CCB reef and bioaccumulation studies of oysters grown on coal ash pellets.

Permitting

Permitting requirements for the construction of the 5-acre CCB reef included:

- U.S. Army Corps of Engineers 404 Permit,
- Texas Water Commission (now Texas Natural Resource Conservation Commission) 401 (C) certification, and
- Texas General Land Office easement agreement.

HL&P was the permittee for the Corps 404 permit and the leaseholder for the General Land Office 20 year easement agreement. Permit delays and pellet production problems dictated that the APDP reef be deployed in two phases. Phase One incorporated 6,000 yds^3 and was deployed in May 1993, while the remaining 6,100 yds^3 was deployed as Phase Two in August 1993. Pre-permit research requirements, negotiated easement terms, and a significant increase in monitoring requirements dictated by the ARMS Committee resulted in an unbudgeted cost burden of $198,739. These costs, well in excess of the original project proposal approved by the Galveston Bay National Estuary Program, were born by HL&P.

Production, Transportation & Deployment Costs

Total cost for producing 12,100 yds^3 of CCB pellets utilized for this APDP was $198,880, equating to $15.85 per yd^3.

A Houston Company, Parker Brothers Inc., transported the CCB pellets from the power plant production site and deployed them via barge for $19.95 per yd^3. Total transportation and deployment costs were $241,395.

Site Selection & Reef Construction

A subcommittee was appointed by the ARMS Committee to employ the following criteria in selecting the APDP reef site:

- Currently devoid of oyster production,
- Open to public harvest of oysters,
- Optimum water conditions for oyster production,
- Relatively firm bay bottom,
- Minimal user conflicts, and
- Adequate depth to accommodate draft of material barges.

ARMS Committee representatives determined that the reef should be deployed in a rectangular configuration approximately 300' X 700'. CCB substrate was to be deployed within the rectangle at an average depth of 18" (plus or minus 6"). Horizontal profile of the material would not be level, but with irregular undulations.

The subcommittee selected a reef site in Central Galveston Bay at approximately Latitude 29° 32.5'N and Longitude 94° 53'W on State Tract #248, or 5.4 miles west of Smith Point in Chambers County. Water depth ranged from 11 - 13', while bottom sediments were relatively firm with only sporadic oyster shell present.

As previously stated, Phase One (6,000 yds3 of CCB pellets) was deployed in May 1993, while Phase Two (6,100 yds3 of CCB pellets) was deployed in August 1993. CCB material was transported to the site on barges and deployed by dragline. Divers periodically surveyed the site during deployment to ensure prescribed reef construction specifications were being met. Site selection and seasonal timing were critical factors ensuring early success of oysters on the CCB reef. The Phase One deployment was carried out just prior to peak oyster spawning in mid-to-late May. This deployment strategy provided optimum timing for reducing competition between oyster and other biofouling organisms for available setting surface. The Phase Two deployment occurred just prior to the secondary oyster spawn in late summer.

Biological Results

For the Phase One CCB pellet deployment, the combination of optimum site selection and deployment, timed with peak oyster spawning activity, resulted in the heaviest recorded natural oyster set on Galveston Bay substrate in at least 40 years. The Phase Two deployment also caught significant numbers of oyster spat which enabled rapid oyster reef development. This site produced market sized oyster (> 3 inches) in less than 18 months. One year after deployment the surface pellets at the site were more than 90% covered with oysters, barnacles, muscles and a variety of colonial hydroids.

Comparison of nekton catch statistics from CCB reef and barren control sites indicates that recycled coal ash can be used to develop productive marine fishery habitats. In about one year, fish production at the CCB reef surpassed that harvested from the control site. Nearly 65% of all organisms sampled at that point in time came from the CCB reef.

In summary, gill-net catches and analysis of biofouling development indicated that the CCB reef had undergone a maturation process in which it gradually evolved from barren artificial substrate to that characteristic of a natural oyster reef. Essential to this maturation was the CCB reef's ability to provide a suitable platform on which encrusting communities attached and became a natural oyster reef. The fact that this CCB reef has and continues to exhibit successional stages in the development of a climax oyster reef community renders it very suitable in the creation of productive marine fishery habitat.

Advantages Offered by CCB Pellets in Oyster Reef Construction

Utilization of CCB pellets offers the natural resource manager numerous advantages including:

- CCB pellets can be produced whereby 100% of the product will meet material size specifications,
- The weight of CCB pellets compares favorably with mined natural shell,
- CCB pellets have a rough texture which is advantageous for the attachment of marine fouling organisms,
- Rounded CCB pellets provide interstitial space in a reef allowing maximum flow of water and nutrients through the reef complex,
- The rounded pellet maximizes available surface space by inhibiting sedimentation of silts,
- Utilization of CCB reduces the need for ash landfill space while simultaneously enhancing marine habitats, and negating the need to mine relic shell and river gravel which can destroy valuable estuarine habitats, and
- Use of CCBs supports recycling goals of Federal and State agencies who have been encouraged to utilize recycled materials in projects when possible.

Lessons Learned

The major lessons learned from this APDP are as follows:

- CCBs derived from burning western coal are environmentally safe and biologically sound reef substrate materials.
- A partnership of industry, agency, and advocacy groups can function well in managing environmental enhancement projects.
- CCB substrate can be cost effective in reef construction and enhancement projects.
- Regulatory agency permitting significantly affected the APDP reef construction schedule and significantly increased costs.
- Reef site selection and timing of deployment are very important in ensuring biological success.
- Results obtained from this APDP should help establish procedures and protocols for future national and international CCB reef evaluations.

Conclusion

Results from this APDP clearly indicate that utilization of CCB substrate for oyster reef construction can be environmentally safe, biologically acceptable and cost effective. CCB substrate provided optimum substrate characteristics for oyster spat settlement. Opportunities currently exist for additional substrate in Galveston Bay, particularly in the central region where significant expanses of bay bottom can support cultch material and salinity regimes are optimal for

oyster production. Construction of large-scale oyster reefs in Galveston Bay, Texas, utilizing CCB pellets, appears to be a viable and innovative tool for our natural resource managers.

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